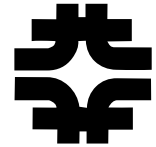
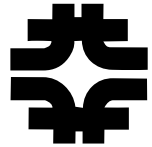


A Future Fermilab: Progress Report

Hugh Montgomery

December 12, 2003

(From) Charge to the FNAL Long Range Planning Committee

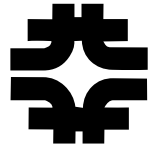


- I would like the Long-range Planning Committee to develop in detail a few realistically achievable options for the Fermilab program in the next decade under each possible outcome for the linear collider. The goal in developing each option should be to optimize the opportunities available at Fermilab in this period for high energy physicists to answer the most important questions in our field. The options should be guided by the priorities for the field as laid out in the HEPAP Subpanel and in the HEPAP response to the Office of Science on the facilities plan.
- The committee should develop scenarios for each of the two cases spelled out by the HEPAP Subpanel.
  - A linear collider project will be built here, starting late in this decade with international support and organization.
  - The linear collider will be built offshore with substantial participation from U.S. High Energy Physics.
- In either case, you should make the following additional assumptions.
  - Fermilab will have a central role in an active U.S. research program at the LHC, both as host of the US-CMS collaboration and as developer of accelerator upgrade plans.
  - Fermilab will carry out the presently approved program of experiments following approval from the national program.

Membership

- Hugh Montgomery (Chair)
- Steve Holmes (Deputy)
- Jeff Appel
- Joel Butler
- Marcela Carena
- Josh Frieman
- Steve Geer
- Chris Hill
- Bob Kephart
- Sergei Nagaitsev
- Jim Strait
- John Womersley
- Gary Feldman, Harvard
- Young-Kee Kim, Chicago
- Peter Meyers, Princeton
- Angela Olinto, Chicago
- Ritchie Patterson, Cornell

Chronology



- January, February, 2003
  - Committee approached, charge drafted and circulated
- Spring and Summer, 2003
  - Sub-committees formed, programs of presentations in committee and discussions
  - Layout of report discussed, space assigned
- Fall, 2003
  - Open Sessions
    - Organised by subcommittees, objective is to indicate direction AND to solicit more feedback
    - Some committees include draft recommendations
  - Drafts of sections of the report
- Now and next month
  - Full committee discussing output from sub-committees
  - Consideration of resources
  - “retreat” in January, to converge on report
- February 2004, submit report

Draft 2005-8 Fermilab Accelerator Experiments Schedule

Revised Annually - This Version from June, 2003

Year		2005	2006	2007	2008
Tevatron Collider				BTeV	BTeV
		CDF & Dzero		CDF & Dzero	CDF & D0
Neutrino Program	B	OPEN	OPEN	OPEN	OPEN
	MI	MINOS	MINOS	MINOS	MINOS
Meson 120	MT		Test Beam	Test Beam	TestBeam
	MC	OPEN	OPEN	OPEN	E906
	ME/P	OPEN	OPEN	OPEN	CKM

This draft schedule is meant to show the general outline of the Fermilab accelerator experiments schedule.
Major components include:
Minimum of 6-8 week shutdown each summer.
6-8 month shutdown for the installation of CDF and Dzero detector upgrades in FYs 2006-7.
Startup of the NuMI operation with the MINOS near and far detectors.
Additional shutdown periods will be added, typically allowing 40 weeks of accelerator operation per year.

RUN or DATA

STARTUP/COMMISSIONING

INSTALLATION

M&D (SHUTDOWN)

23-Jun-03

Note what is open

Draft 2009-12 Fermilab Accelerator Experiments Schedule

Revised Annually - This Version from June, 2003

Year		2009	2010	2011	2012	
Tevatron Collider		BTeV	BTeV	BTeV	BTeV	OPEN
			OPEN	OPEN	OPEN	OPEN
Neutrino Program	B		OPEN	OPEN	OPEN	OPEN
	MI		OPEN	OPEN	OPEN	OPEN
Meson 120	MT		Test Beam	Test Beam	Test Beam	TestBeam
	MC		E906-DrellYan	E906-DrellYan	OPEN	OPEN
	ME/P	CKM	CKM	CKM	CKM / OPEN	OPEN

This draft schedule is meant to show the general outline of the Fermilab accelerator experiments schedule.
Major components include:

- A minimum 6-8 week shutdown each summer.
- Startup of the BTeV experiment, including 3-month shutdown for low beta installation.
- Startup of the CKM experiment.
- Startup of the E906 experiment.

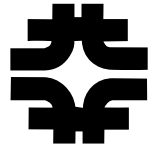
Additional shutdown periods will be added, typically allowing 40 weeks of accelerator operation per year.
The draft schedule will be updated as more precise information is made available, or projections change.

- RUN or DATA
- STARTUP/COMMISSIONING
- INSTALLATION
- M&D (SHUTDOWN)

23-Jun-03

End of decade not yet clear

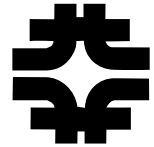
Sub-committees/Working Groups



Physics Convenor: **Chris Hill**	**Neutrinos** Convenor: **Gary Feldman**	**Linear Collider** Convenor: **Steve Holmes**	**Large Hadron Collider** Convenor: **John Womersley**	**Proton Driver** Convenor: **Bob Kephart**
Accelerator R&D Convenor: **Steve Geer**	**Particle Astrophysics** Convenor: **Josh Frieman**	**Non-(Particle Physics)** Convenor: **Joel Butler**	**Resources** Convenor: **Hugh Montgomery**	**International Lab Issues** Convenor:

Membership of subcommittees goes way beyond the membership of the full committee.

Proto-recommendations

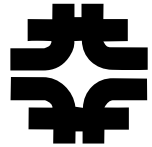


- Primarily coming from the relevant sub-committee/working group
- Not hashed out in full committee
- Not matched to resources
- Often a precis by me to fit on single sheet
- Sometimes informed by e-mails in preparation of this talk

All are subject to change

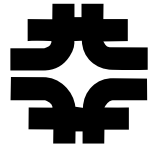
You still have time to give input

Physics Landscape Proto-recommendations



- Fermilab should aggressively assert itself as a world class and national leader in the fundamentally important, leading edge science of accelerator based elementary particle physics.
- Fermilab should strive to maintain a strong position in energy frontier particle physics. (LHC, LC)
- The Fermilab plan for the future must be flexible and should exploit breadth in the realm of accelerator based particle physics while striving to make new discoveries and to accommodate and exploit them.
- Fermilab should aggressively plan to be a world-class neutrino facility.
- Fermilab should strive to maintain and expand its leadership role in Particle Astrophysics, which provides probes of fundamental physics that complements accelerator experiments.

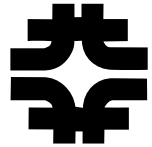
Accelerator R&D



- Of order 25 talks in the committee meetings
- Talks in open session
  - Introduction — S. Geer
  - R&D at A0 and SCRF R&D — H. Edwards
  - MUCOOL and Neutrino Factory R&D — A. Bross
  - Magnet R&D — J.Strait
  - Accelerator Theory, Simulation and the Student Program — M. Syphers
  - University Perspective — C. White
  - Prototype Recommendations — S. Geer

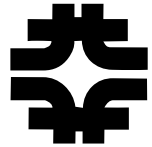
- Most of our science is dependent on accelerator R&D done many years ago.
- The future of that science depends on the R&D we do today.
- There is a general sense that we have systematically short changed this work.
- Lots of the work is immensely interesting physics

Accelerator R&D Draft subcommittee Recommendations



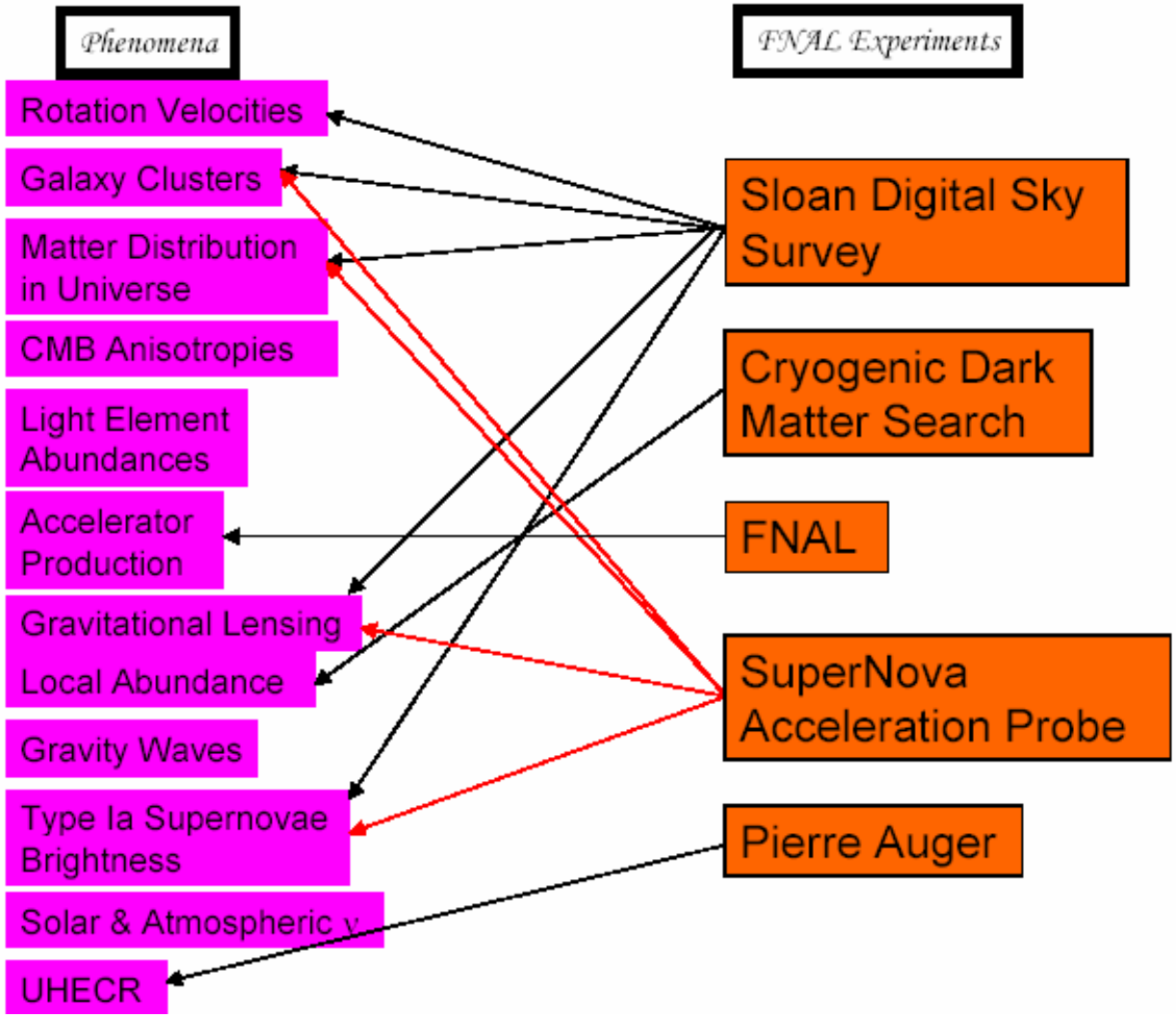
- We recommend that:
- accelerator R&D programs aimed at the long-term be agreed and protected
- accelerator R&D programs aimed at medium and long-term be examined to to establish the goals and the level of support needed for success.
- accelerator R&D programs at Fermilab be recognized as an integral part of the scientific program and advertised as such
- the Director examine the peer review and approval process for accelerator R&D and modify to improve uniformity and visibility of the process and program to the particle physics community.
- encourage collaboration with the Universities and in National and International efforts

Detector R&D: Draft Recommendations



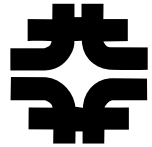
- Fermilab Testbeams
- Radiation Testing Facilities
  - Rad. Damage Facility enhancement.
  - Neutron Therapy facility use.
- Actively encourage R&D.
  - Identify point of contact
  - Establish R&D program
  - Participant funding of R&D projects
  - Ask for proposals and review them
  - Formalize role in supporting University efforts
- Use facilities in interim periods, work for others?

Particle Astrophysics - a view



From Scott Dodelson's open session talk

Particle Astrophysics



- Not quite proto-recommendations
- Particle Astrophysics *Center*
  - Aim is to nurture and control the Astrophysics efforts and help integrate
  - Interdivisional structure
  - Common space to foster interactions
  - Have a leader of stature
- Already have strong astrophysics program
  (FNAL was the pioneer among HEP labs)
  - Dark Matter (SDSS, CDMS,SUSY searches)
  - Dark Energy (SNAP/JDEM nascent)
  - Ultra high energy cosmic rays (Auger)

  »
- Astroparticle is growing, how big should the program become?
  - SDSS Program at a point which encourages discussion.
  - FNAL Technical Expertise significant (Focal Plane Arrays)
  - You see some of the List, add CTIO and LSST to capture the discussions.
  - PAC getting augmented to handle the discussion.

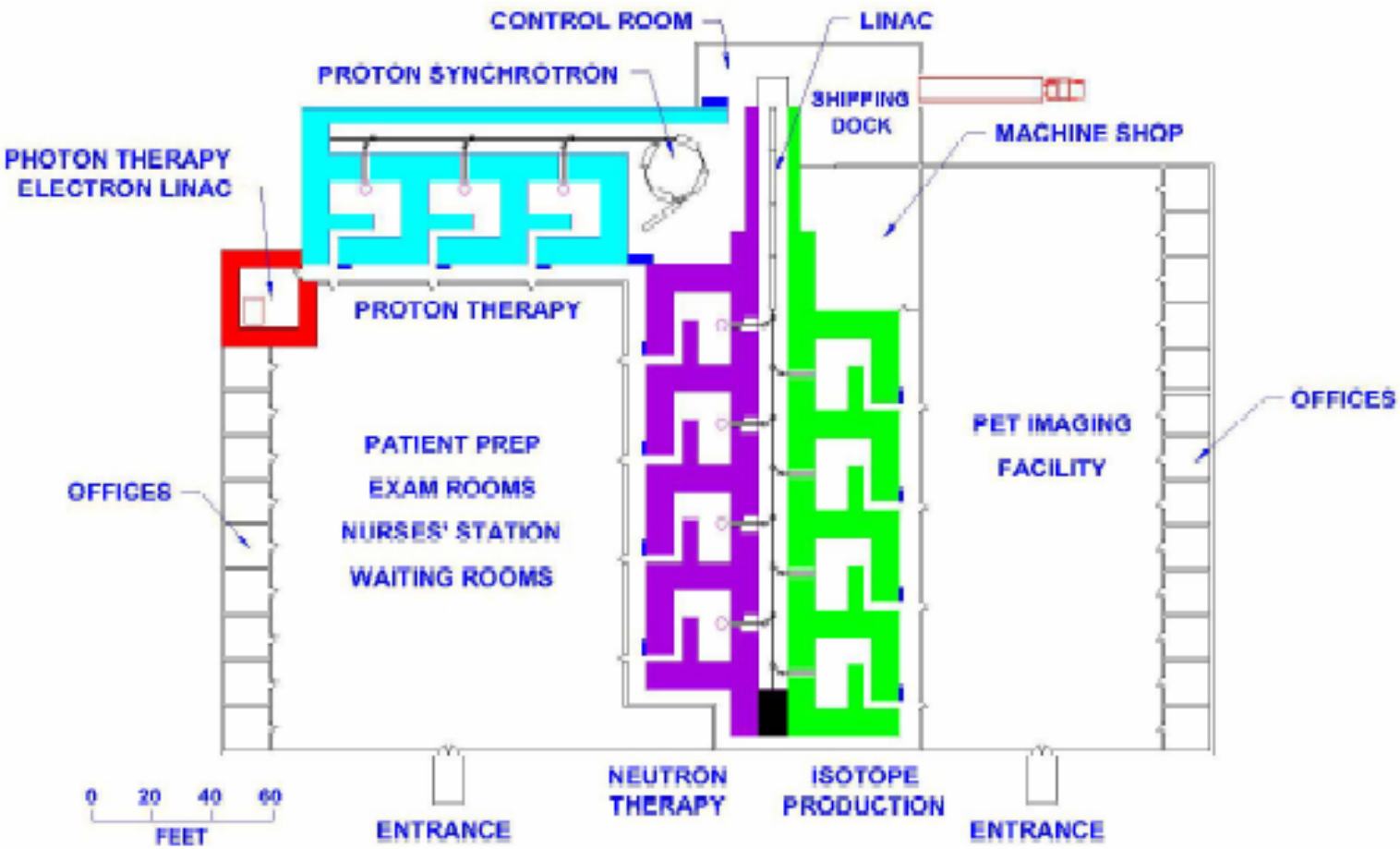
Non Particle Physics

- The stuff that's really close to the Lab mission
- Open session:

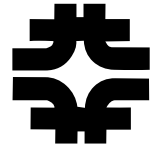
A Possible Medical Accelerator Facility Near Fermilab	**A. Lennox**
– **Possible Computing Initiatives**	**R. Tschirhart**
– **Non HEP Uses of HEP Instrumentation**	**D. Christian**
– **Research with Low Energy Accelerators**	**C. Johnstone**
– **Radiation Physics R&D**	**K. Vaziri**
– **GSI Future Project**	**W. Foster**

- (there is work going on to revive the existing Neutron Therapy Facility)

Hadron Therapy Facility
First Floor - Plan View

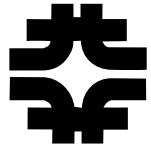


Non-particle Physics protorecommendations



- **Fermilab should:**
  - Incorporate limited, controlled set of science and engineering projects
  - Review and adjust approach to such
  - Support Hadron Therapy Facility initiative
  - Expand education & outreach

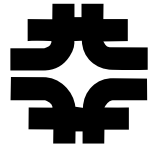
Large Hadron Collider – Open Session



Outline Agenda

- Overall Introduction (H. Montgomery)
- Vision for LHC at Fermilab (J. Womersley)
- LHC Accelerator Research Project (J. Strait)
- Detector R&D (J. Freeman)
- CMS Tier 1 Center and Computing (L. Bauerdick)
- Ideas for a Theory Center (M. Carena)
- Ideas for Physics Analysis (R. Demina)

Large Hadron Collider



A vision for the LHC at Fermilab

- A role in LHC that is commensurate with the scale of Fermilab now and our future hoped for role in world HEP
- CMS Physics Analysis Center
  - Not just
    - Allow Fermilab to be a very competent collaborating institution
    - "the best place to get your data from"
    - "the best place to be if you can't be at CERN"
  - But "the best place to be if you want to do physics"
    - Why not?
  - Must enhance US physics potential overall, and improve the return on US investment in CMS and LHC
- A leading center (the leading center?) for LHC theory/phenomenology
- A leading center (the leading center?) for detector development and accelerator development for the LHC luminosity upgrades

- Resources in the funded CMS Research Program, discussions with University and FNAL physicists. The trick is to make it happen.

Large Hadron Collider- proto recommendations

- Recommend that FNAL:

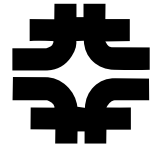
- visibly and enthusiastically embrace LHC as central component.
- continue to promote and support CMS
- encourage efforts to establish Physics Analysis Center
- take steps to increase involvement of FNAL physicists in analysis, core for future.

- encourage involvement in detector R&D

- should lead the LHC Accelerator Research Program..
- recognize the collaboration with CERN on the LHC accelerator
- continue funding of high field magnet R&D

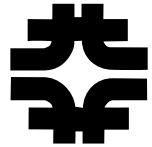
- consider alternative organizational models for LHC activities

Linear Collider Status



- International Linear Collider Steering Committee under ICFA
  - Regional Committees
- Governance documents complete or in draft.
- US LC Accel Committee has completed study of Cold & Warm options “as if sited in US”.
- Technologies
  - R1s supposed to be resolved this year
    - Power distribution was met last week for warm.
- Technology Choice
  - Committee in place,
  - 1st Meeting in UK in January.
  - Charge in advanced draft form
  - Report by end of 2004

Linear Collider Governance (Kalmus Model)



- **The GLCP should be sited near an existing "Host" laboratory, from which it should be managerially wholly independent. This would:**
  - **save much of the cost of establishing the infrastructure, support, and services that are needed by any large-scale project, while keeping the number of staff directly employed by the GLCP low;**
  - **provide the necessary academic and technical ambience from the outset;**
  - **reduce the cost of ultimate closure of the GLCP by ensuring that facilities owned by it are kept to a minimum.**
- Relations between the GLCP and the Host Laboratory, and the role of the Host State, are considered in more detail in the full ECFA report

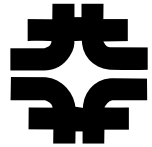
7

This struck a chord in sub-committee and in open session

(The host lab gets to maintain a physics program independent of LC.)

But still an open, international entity in the US will be a challenge.

Linear Collider Recommendations

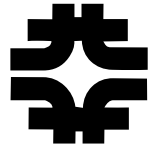


- Recommend that:

- **A full-time person should be appointed within the Directorate with responsibility for coordinating and directing all Fermilab activities and providing communications to outside institutions on linear collider. This should include both creation and execution of a coherent plan addressing:**
  - **Technology R&D, Site studies, Public outreach, Support of the Fermilab scientific staff, Governance models**

  and incorporating:
  - **Establishment of a realistic timeline in consultation with the USLCSG**
  - **Preparation of a bid to host the Engineering Test Facility**
  - **Preparation of the Fermilab component of the U.S. bid to host an international linear collider facility.**
  - **Fallback plans in the event that the linear collider is sited elsewhere**

Linear Collider Recommendations

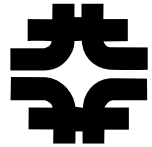


Recommend that:

- **Fermilab initiate efforts to coordinate development of design studies for both warm and cold ETFs, in collaboration with international partners, with a goal of siting the ETF for the chosen technology at Fermilab.**

- **Fermilab planning should be based upon the host laboratory/international project model.**

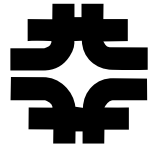
Linear Collider (Steve Holmes)



Conclusions and (Personal) Opinions

- The opportunity to host a physics frontier facility comes rarely. We cannot "pass".
- Fermilab has a responsibility both to our staff, and to the national and international communities to establish ourselves as an excellent candidate for the LC host laboratory.
- We should commit our laboratory to a plan that maximizes the likelihood of Fermilab becoming host lab.
- Governance models similar to that described by Kalmus allow us to do this without holding the future of the laboratory hostage to a process (getting to a LC construction start) that may take a long time to culminate or may result in the LC being constructed elsewhere.
- The development of a backup plan should not be interpreted as a lack of commitment.

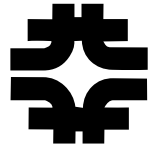
From "Neutrinos" Group Work Plan



- Overall Goal
  - Plan a Fermilab Neutrino Program that is capable of providing definitive measurements of the currently unmeasured neutrino oscillation parameters, θ_{13}, sign(Δm_{13}^2) and δ

- The overall goal assumes that a program that is sufficiently powerful ….. will also provide a wealth of other oscillation and non-oscillation physics. The word capable … should be interpreted to include this.

Neutrinos

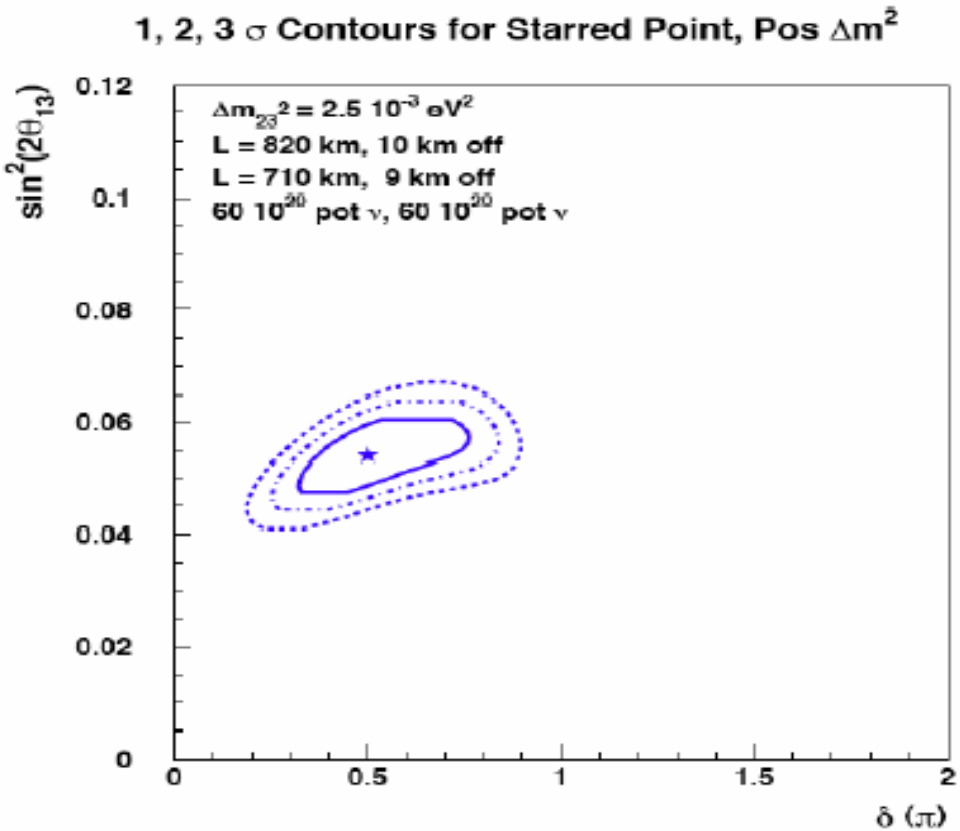


- Issues in Neutrino Physics — S. Parke
- Off-Axis Experiment — G. Feldman
- Reactor Experiment — J. Link
- Neutrino Factory — S. Geer

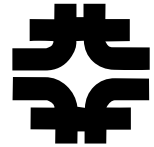
- Prospects if MiniBooNE Has a Positive Signal — B. Kayser
- Non-Oscillation Physics — K. McFarland
- Proto-Recommendations — G. Feldman

Neutrinos

NuMI 3 yr ν, 3 yr $\bar{\nu}$, 2 Detectors and Proton Driver



Neutrinos - Long Baseline proto-recommendations

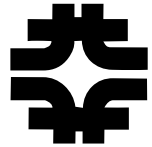


- That Fermilab proceed with the Off-Axis experiment as part of a step-by-step program to eventually measure all of the neutrino mixing parameters.
- That Fermilab proceed with the construction of a proton driver to provide a 2 MW 120 GeV beam.
- There will be other recommendations concerning Neutrino Factory work and possibly about the off-site reactor initiative.

Proton Driver

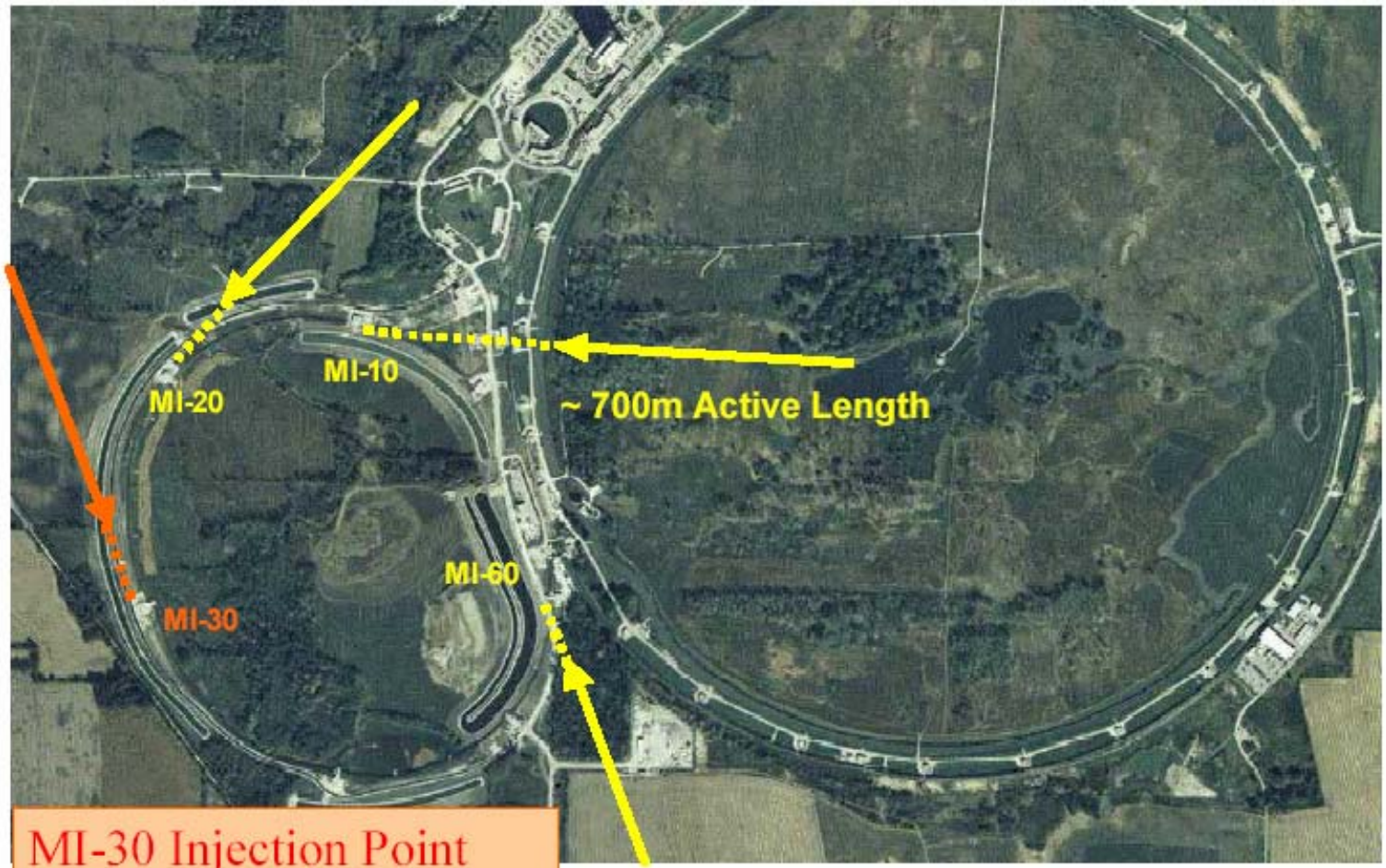
- Goals
- Understand and summarize the physics, operational, and technical arguments for constructing a new high intensity proton source at Fermilab (Proton driver).
- Summarize the arguments pro and con for the two options for a Proton Driver:
  - **8 GeV Circular booster replacement**
  - **8 GeV Superconducting linear accelerator (the same technologies as SNS and Tesla)**
- Define the steps including R&D program that would allow Fermilab to gain approval for such a machine.
- Summarize the funding, schedule, and manpower considerations
- Recommend a plan of action and a near-term level of laboratory effort that should be devoted to this task.

Proton Driver (Peter Myers)

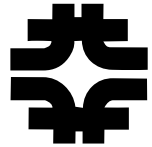


- **Primary motivation is the Long Baseline Neutrino Program**
- **Proton Driver could support a broad physics program of its own**
  - **Two Fermilab studies**
  - **Short-baseline neutrino oscillation**
    - **if MiniBooNE confirms LSND**
    - **multiple sterile neutrinos?**
  - **Low-energy neutron source**
    - **optimize for elementary particle physics**
  - **Low-energy muon source**
- **Head-start for bigger projects?**
  - **SC Linac a warm-up (cool-down?) for LC**
  - **Neutrino Factory R&D/source**

Proton Driver – SC Linac



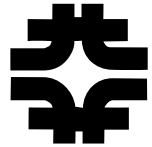
Proton Driver – SC Linac



8 GeV LINAC			
Energy	GeV	8	
Particle Type	H- Ions, Protons, or Electrons		
Rep. Rate	Hz	10	
Active Length	m	671	
Beam Current	mA	25	
Pulse Length	msec	1	
Beam Intensity	P / pulse	1.5E+14	(can be H-, P, or e-)
	P/hour	5.4E+18	
Linac Beam Power	MW avg.	2	
	MW peak	200	

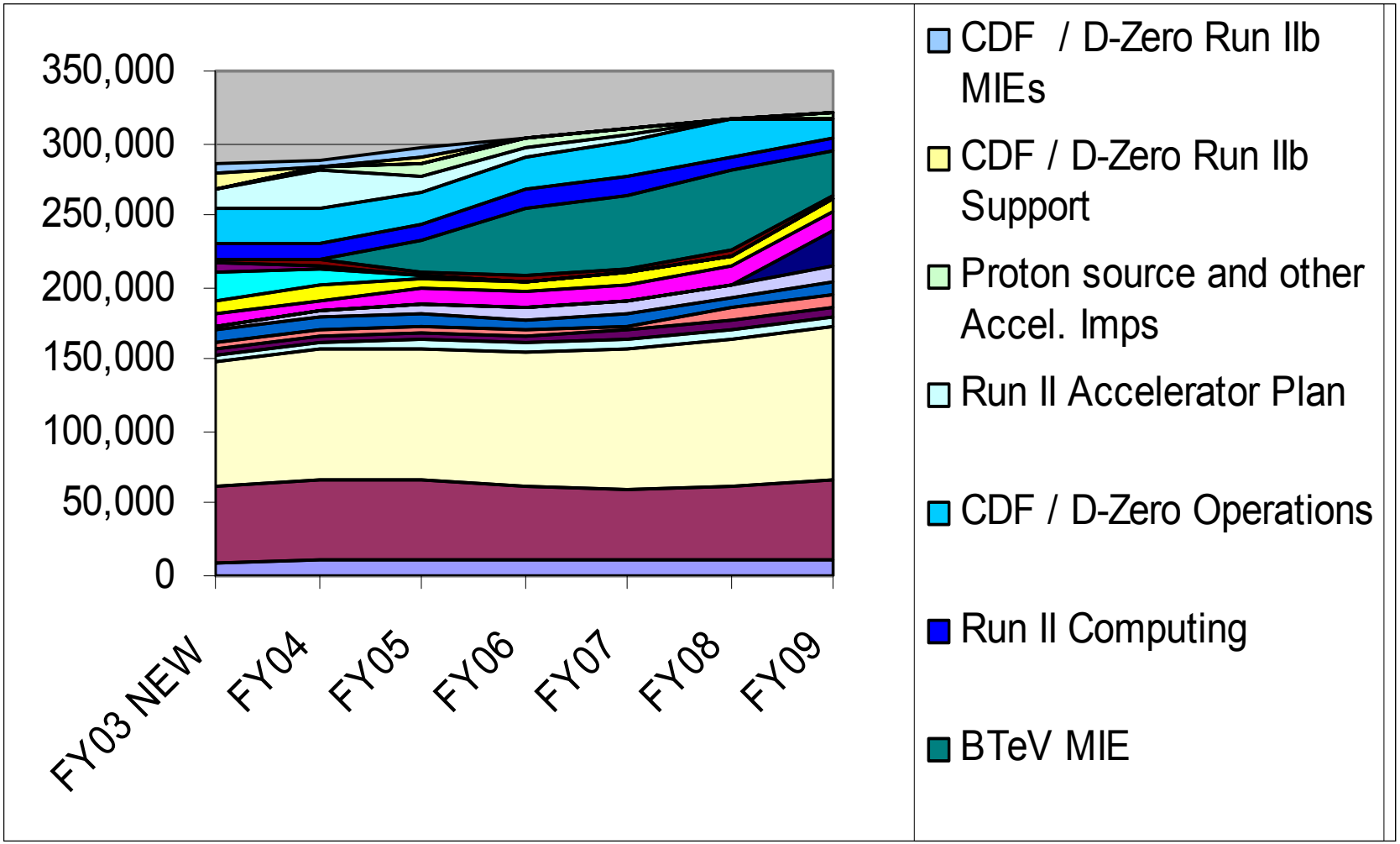
MAIN INJECTOR WITH 8 GeV LINAC			
MI Beam Energy	GeV	120	
MI Beam Power	MW	2.0	
MI Cycle Time	sec	1.5	filling time = 1msec
MI Protons/cycle		1.5E+14	5x design
MI Protons/hr	P / hr	3.6E+17	
H-minus Injection	turns	90	SNS = 1060 turns
MI Beam Current	mA	2250	

Proton Driver – proto-recommendations

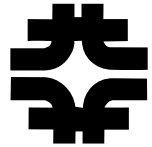


- We recommend that Fermilab
- adopt as its next accelerator construction project the creation of a 1-2 MW proton source (aka Proton Driver). We envision this project to be a coordinated combination of upgrades to existing machines and new construction. We believe this recommendation to be valid in any plausible linear collider scenario.
- adopt a superconducting 8 GeV linear accelerator as the preferred option to replace the existing Linac-Booster system.
- create a group charged to submit to DOE documentation sufficient to achieve a statement of mission need (CD-0). The group will elaborate the physics case, produce a Technical Design Report, prepare project management documentation including cost and schedule estimates, and prepare a plan for the required R&D.

Resources- Short Term



Resources

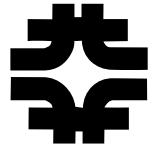


- Start from 6 year model being used for discussions with DOE now.
  - Note that G&A is included in each line.
- Extend for a further few years to include 2017.
- Use 2% increase per year to inflate individual items (if know no better)
- Make a few intelligent moves, for example recognize that when BTeV stops there is a drop in the Accelerator Operations.
- Add in a profile corresponding to the desired new initiative.
  - Linear Collider
  - Proton Driver
- **Not (yet) done**
  - Delve into the large parts of the Accelerator Operations, and the Direct Support to see what else goes away.
  - Scrub for double counting between existing elements and elements added
  - Fix manifest inconsistencies
  - Check that we have not left in some stupid things (we have)

Balancing will only be broad brush

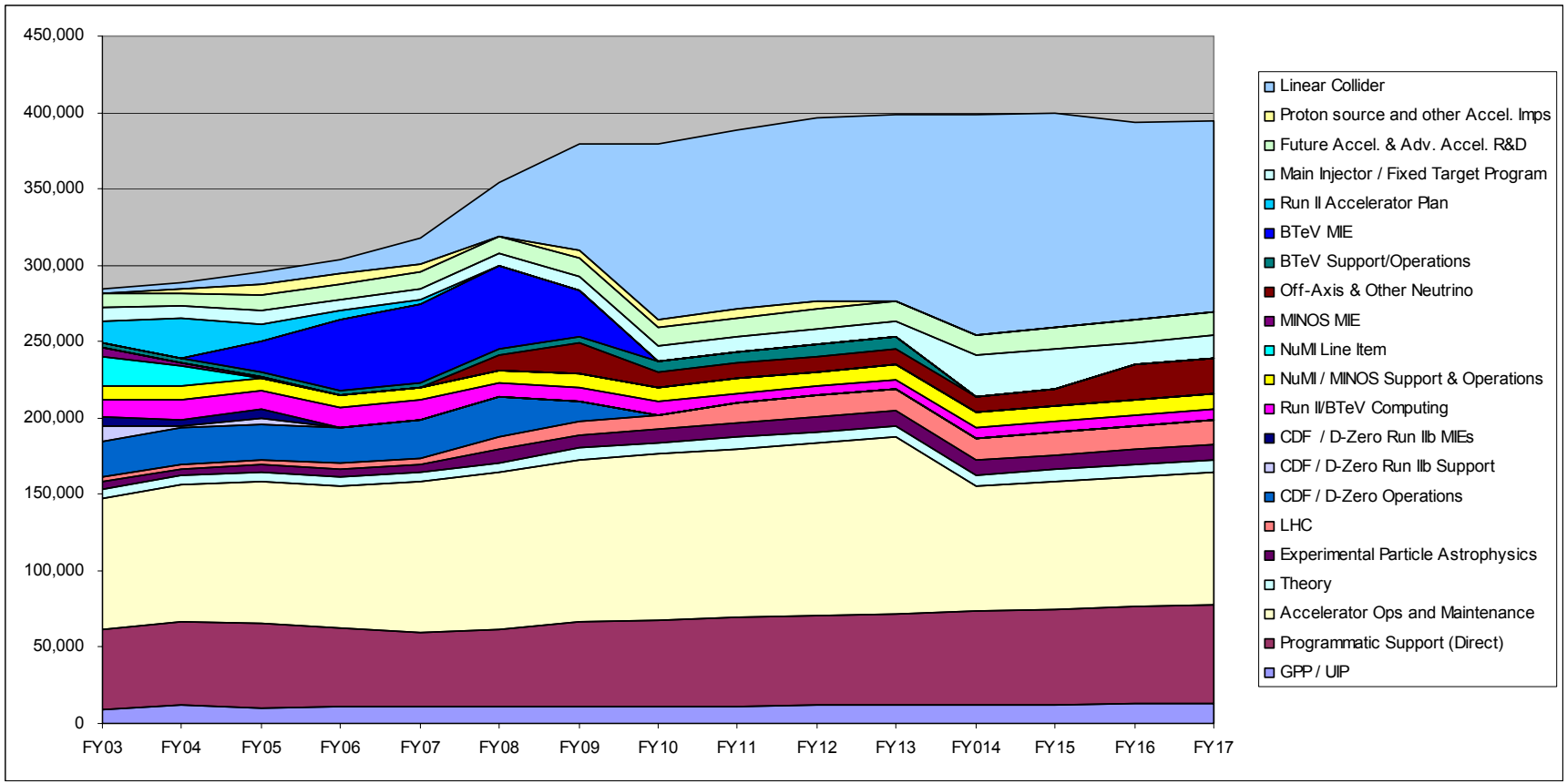
We wanted to give a sense of what we will try to do!

Resource Models



- **Linear Collider**
  - Ramp up through the end of the decade
  - Plateau at about 30% of lab
  - Look at integral through 2020.. Get $AY1.5B
  - Think of this as ~FNAL contribution??
- **Proton Driver**
  - Put in $AY500M as representative of say:
    - Copper FE Linac $FY03 36M
    - 5 GeV SC Linac $FY03 312M
    - MI Improvements $FY03 72M

Resources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FY03
FY04
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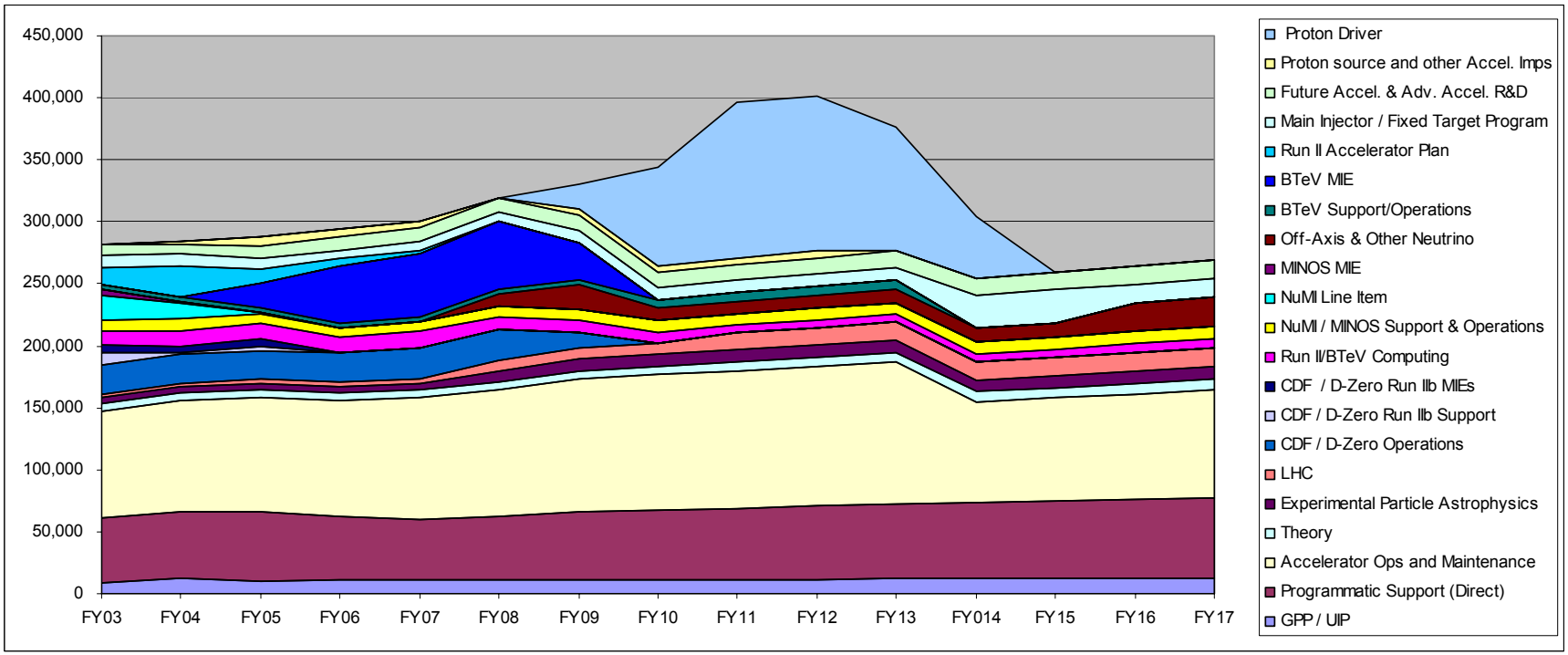
FY07
FY08
FY09
FY10
FY11
FY12
FY13
FY014
FY15
FY16
FY17
Linear Collider
Proton source and other Accel. Imps
Future Accel. & Adv. Accel. R&D
Main Injector / Fixed Target Program
Run II Accelerator Plan
BTeV MIE
BTeV Support/Operations
Off-Axis & Other Neutrino
MINOS MIE
NuMI Line Item
NuMI / MINOS Support & Operations
Run II/BTeV Computing
CDF / D-Zero Run IIb MIEs
CDF / D-Zero Run IIb Support
CDF / D-Zero Operations
LHC
Experimental Particle Astrophysics
Theory
Accelerator Ops and Maintenance
Programmatic Support (Direct)
GPP / UIP

Resources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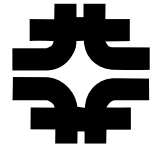
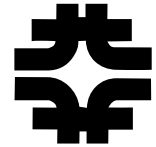
Resource Conclusions



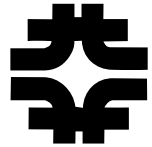
- **Linear Collider**
  - **$AY 1.5B cannot (yet) be achieved under the 2% p.a bound.**
  - **$AY 1.5 does fit under a 4% p.a. bound.**
- **Proton Driver**
  - **Profile 20, 80, 125, 125, 100, 50**
  - **Does not (yet) fit under a 2% p.a bound**
  - **Can fit under a 4% p.a. bound**
- **Balancing will only be broad brush**

The Next Steps



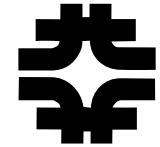
- December 15 – Plenary Meeting
- January 9-10, retreat
- Complete Report
- Discuss and Release in February??

Conclusions



- **Fermilab will have a Challenging and Exciting long term Future with:**
  - **Large Hadron Collider physics center**
  - **An Onsite Accelerator-Based program with a combination of Linear Collider and Proton Driver based Neutrino Program.**
  - **Particle Astrophysics**
  - **Accelerator R&D**
  - **Medical Physics**
  - **…. And more**
- **If we work together, we can make it happen!**
- **Thanks to the Committee, the MANY participants, and to the many who have attended the open sessions.**

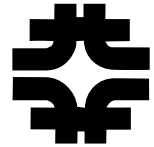
Spares



Outline

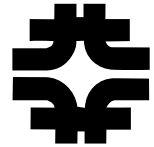
- Charge, Membership, Context
- Discussions and Draft Recommendations from sub-committees
- Next Steps

Website



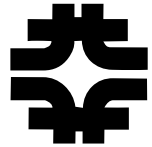
- http://www.fnal.gov/directorate/Longrange/Long_range_planning.html
- http://www.fnal.gov/directorate/Longrange/FLRPC_charge.html
- http://www.fnal.gov/directorate/Longrange/FLRPC_Memo.html
- http://www.fnal.gov/directorate/Longrange/LRP_WorkGroups.html
- http://www.fnal.gov/directorate/Longrange/Open_Sessions.html

Context



- HEPAP Bagger-Barish 2001-2
- HEPAP – P5 2003
- Office of Science Facilities 20 yr Plan
- Existing FNAL Program
- Other Planning Exercises

Linear Collider FNAL view



- FNAL strongly committed to being a full partner in a future LC
- FNAL is planning to
  - Build up accelerator R&D effort on LC (currently funding limited)
  - Build up a group to work with University groups doing R&D on accelerator and detector
- FNAL as a site for a future LC is being actively explored
  - Proposed by Director in 2001
  - Strong base of expert manpower and infrastructure
  - Excellent locations nearby
  - Good geology
  - Good political environment

Proton Driver – New Booster